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(54) Long chain diol diesters as low calorie fat mimetics.

(57) Long chain diol diesters, notably 11- to 30- carbon aliphatic chains having two vicinal fatty acid esters or dicarboxylate-extended fatty acid esters, or two fatty acid esters or dicarboxylate-extended fatty acid esters separated by one or two methylene groups, attached to one end of the chain, are edible, preferably partially digestible, fat replacements for foods and pharmaceuticals.

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## LONG CHAIN DIOL DIESTERS AS LOW CALORIE FAT MIMETICS

BACKGROUND OF THE INVENTION

This invention relates to the use of long chain diol diesters, notably aliphatic chains of 11 to 30 carbons having two fatty acid esters or two dicarboxylate-extended fatty acid esters, or two fatty acid esters or two dicarboxylate-extended fatty acid esters, as substituents separated by one or two methylene groups and attached to one-end of the chain, as edible, Preferably partially digestible, fat replacements for foods and pharmaceuticals.

Since fats provide nine calories per gram compared to four calories per gram provided by protein or carbohydrates, major research efforts toward reduction of caloric intake for medical or health reasons have focused on ways to produce food substances that provide the same functional and organoleptic properties as fats, but not the calories.

A major strategy for developing low calorie replacement fats has been to structurally re-engineer natural triglycerides in such a way as to retain their conventional functional properties in foods, while removing their susceptibility toward hydrolysis or subsequent absorption during digestion. To this end, the fatty acids attached to glycerol have been replaced with alternate acids (U.S. Pat. No. 3,579,548 to Whyte); groups have been inserted between the fatty acids and the glycerol backbone ("propoxylated glycerols", Eur. Pat. Ap. No. 254,547 to White and Pollard); the ester linkages have been replaced by ether linkages (U.S. Pat. No. 3,818,089 to Bayley and Carlson, and Can. Pat. No. 1,106,681 to Trost); the ester linkages have been reversed (U.S. Pat. No. 4,508,746 to Hamm); and the glycerol moiety has been replaced with an alternate alcohol (e.g., ethylene glycol in U.S. Pat. No. 2,924,528 to Barskey *et al.*, and U.S. Pat. No. 2,993,063 to Alsop and Carr).

A second major approach to the development of a low calorie fat replacement has been to explore or synthesize nonabsorbable polymeric materials structurally unlike triglycerides, but having physical properties similar to edible fat. Mineral oil was disclosed as early as 1894 (U.S. Pat. No. 519,980 to Winter), and, more recently, polydextrose (U.S. Pat. No. 4,631,196 to Zeller), polyglucose and polymaltose (U.S. Pat. No. 3,876,794 to Rennhard), polysiloxane (Eur. Pat. Ap. No. 205,273 to Frye), jojoba wax (W. Ger. Pat. No. 3,529,564 to Anika), and polyethylene polymers (E. Ger. Pat. No. 207,070 to Mieth, *et al.*) have been suggested.

A third major strategy combines the first two. Rather than restructure triglyceride molecules or find a substitute structurally very dissimilar, this approach explores the use of various polyol esters, compounds which have numbers of fatty acid groups in excess of the three in conventional fat triglycerides, as nonabsorbable fat replacements. Fully esterified sugar alcohols were suggested as fat replacements during World War I (notably mannitol, Lapworth, A., and Pearson, L.K., and Halliburton, W.D., *et al.*, 13 *J. Biol. Chem.* 296 and 301 (1919)); Minich suggested esterifying pentaerythritol, a tetrahydric neopentyl sugar alcohol which can be formed from pentaerythrose, in 1960 (U.S. Pat. No. 2,962,419); and the Southern and Western Regional Research Laboratories of the U.S.D.A. investigated the feasibility of using amylose esters as new-type fats during the 1960's (see Booth, A.N., and Gros, A.T., 40 *J. Amer. Oil Chem. Soc.* 551 (1963) and the references cited therein). More recently, sucrose polyesters have been suggested (U.S. Pat. No. 3,600,186 to Mattson and Volpenhein). The caloric availability and digestibility of a series of dimeric and polymeric glycerides including diglyceride esters of succinic, fumaric, and adipic acids, and polymeric fats from stearic, oleic and short-chain dibasic acids were assessed by the U.S.D.A. group cited *supra*, and polyglycerol esters have since been suggested (U.S. Pat. No. 3,637,774 to Babayan and Lehman).

Nondigestible or nonabsorbable triglyceride analogues, polyol esters, and polymeric materials have proved disappointing as fat replacements when tested in feeding trials, where gastrointestinal side effects occurred, in some cases so extreme that frank anal leakage was observed (for recent reviews, see Hamm, D.J., 49 *J. Food Sci.* 419 (1984), Haumann, B.J., 63 *J. Amer. Oil Chem. Soc.* 278 (1986), and LaBarge, R.G., 42 *Food Tech.* 84 (1988)). Nondigestible fats act as a laxative and are expelled from the body, eliciting foreign body reactions like those early documented for mineral oil (Stryker, W.A., 31 *Arch. Path.* 670 (1941), more recently summarized in Goodman and Gilman's *Pharmacological Basis of Therapeutics*, 7th ed., Macmillan Pub. Co., N.Y. 1985, pages 1002-1003). Polyglycerol and polyglycerol esters, for example, suggested as fat replacements *supra*, have been suggested for use as fecal softening agents as well (U.S. Pat. No. 3,495,010 to Fossel). A number of remedies have been recommended to combat the anal leakage observed when sucrose polyesters are ingested (e.g., employing cocoa butters, U.S. Pat. No. 4,005,195 to Jandacek, or incorporating saturated fatty groups, Eur. Pat. Ap. No. 233,856 to Bernhardt), and

dietary fiber preparations have been incorporated into polysaccharide and/or polyol-containing foodstuffs to help inhibit the diarrheal effect (U.S. Pat. No. 4,304,768 to Staub *et al.*).

## SUMMARY OF THE INVENTION

Ways were accordingly sought of providing a fat mimetic having substantially fewer calories than normal fat and more compatible with normal digestion, thus minimizing or avoiding laxative side effects, preferably a partially digestible fat replacement which may, if desired, be engineered to provide essential or desirable fatty acids.

In the practice of this invention, long chain diol diesters, notably aliphatic chains having 11 to 30 carbon atoms to which are attached two vicinal fatty acid ester or dicarboxylate-extended fatty acid ester groups, or two fatty acid ester or dicarboxylate-extended ester groups separated by one or two methylene groups at one end of the chain, comprise a new class of edible, preferably partially digestible, fat replacements for food and pharmaceuticals.

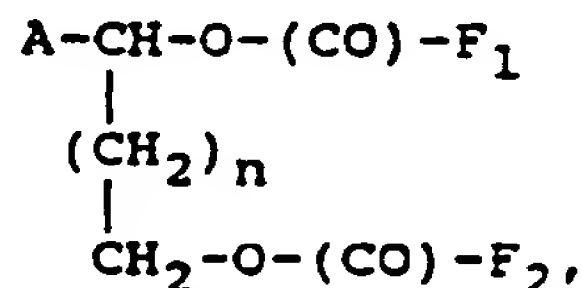
Further alternative definitions of the invention are hereinafter set out in the claims.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although most lipids are derivatives of glycerol, many organisms of animal, plant and microbial origin also contain small amounts of lipids that are derivatives of diols. These include mono- and diacyl esters and mixed alkyl and alkenyl ester fatty acid derivatives of ethylene glycol, 1,2- and 1,3-propanediols, 1,3- 1,4- and 2,3-butanediols, and 1,5-pentanediol isolated from such widely differing tissues as mutton fat, fish liver, egg yolks, corn seeds, yeast and rat liver (Gurr, M.I., and James, A.T., *Lipid Biochemistry*, 3rd ed., Chapman and Hall, New York, 1980, pp. 91-92). These lipids, first separated from neutral lipid components using high-temperature gas-liquid chromatography, were named "diol lipids" (Bergelson, L.D., *et al.* 116 *Biochim. Biophys. Acta* 511 (1966)). Diol lipids have since been discovered among the ionic lipids, and generally comprise a concentration of 0.5 to 1.5% that of glycerol derivatives (Smith, E.L., *et al.* *Principles of Biochemistry: General Aspects*, 7th ed., McGraw-Hill, New York, 1983, p. 117), though skin surface lipids can contain much higher concentrations (25-30% and above; see Nikkari, T., and Haahti, E., 164 *Biochim. Biophys. Acta* 294 (1968) and Brind, J.L., *et al.* 84B *Comp. Biochem. Physiol.* 403 (1986)).

Diol lipids have not figured into the reported fat replacement research which has focused, instead, on ways of providing edible fat replacements for triglycerides. This invention is based on the finding that certain long chain diol diesters which are analogues of both diol lipids, a minor component of natural fat, and triglycerides, the major component, and combine the features of both components, comprise a new class of fat mimetics, suitable for use in foods and pharmaceuticals.

The compounds of the present invention can be defined by the following structural formula:



where

A is an alkyl group having from 7 to 28 carbons,  
n is 0 to 2, and

F<sub>1</sub> and F<sub>2</sub> are aliphatic groups having 1 to 30 carbons or dicarboxylate-extended aliphatic groups of the formula  $-(\text{CH}_2)_m\text{-(CO)-O-R}$ , where m = 1 to 4, and R contains 1 to 30 carbons.

The compounds of this invention have two vicinal fatty groups F<sub>1</sub> and F<sub>2</sub>, either aliphatic groups or dicarboxylate-extended aliphatic groups, separated by one or two (n in the above formula) methylene groups. In compounds having simple fatty acid esters, the compounds are analogues of natural diol lipids, except that the compounds further have an alkyl group, A, having as few as 7 and as many as 28 carbon atoms. In this respect, this class of compounds are also analogues of natural triglycerides, with an end fatty

acid ester group replaced by an alkyl group. While not wishing to be bound to any theory, it is believed that this combination of features enable the compounds of this invention to be well suited as fat mimetics.

This invention comprises long chain diol diesters. By "long chain" is meant aliphatic diol esters having 11 to 30, more narrowly 11 to 20, carbons attached to one another by single, double, or triple bonds.

5 Examples of diols which may form the compound backbones are saturated or unsaturated undecanediols, dodecanediols, tridecanediols, tetradecanediols, pentadecanediols, hexadecanediols, heptadecanediols, octadecanediols, nonadecanediols, icosanediols, montanediols, and the like. Chemical formulae and descriptions include isomeric variations. The diols may be normal, *iso* and *neo*, having primary, secondary and tertiary hydroxyl groups.

10 Attached in ester linkage to the diols comprising the compound backbones of this invention are two fatty acid residues in ester linkage or dicarboxylate-extended ester linkage. The term "fatty acid" used here means organic fatty acids of the formula  $\text{RCOOH}$  having 2 to 31 carbon atoms. The fatty acids may be synthetic or natural, saturated or unsaturated, with straight or branched chains. Examples of fatty acids that can be used in this invention are acetic, propionic, butyric, caproic, caprylic, pelargonic, capric, lauric, 15 undecanoic, myristic, palmitic, stearic, arachidic, behenic, oleic, linoleic, linolenic, eleostearic, and arachidonic acids. Mixtures of fatty acids may be used, such as those obtained from non-hydrogenated or hydrogenated soybean, safflower, sunflower, sesame, peanut, corn, olive, rice bran, canola, babassu nut, coconut, palm kernel, cottonseed, palm, or butter oils. Specific fractions of natural or processed oils may also be used. Halogenated fatty acid derivatives may also be used, such as brominated fatty acids.

Alternatively,  $\text{F}_1$  and  $\text{F}_2$  attached to the diol may be dicarboxylate-extended fatty groups. By "dicarboxylate-extended" or "dicarboxylic acid-extended" fatty groups is meant groups formed from the reaction of fatty alcohols ( $\text{ROH}$  using the nomenclature of the formula above, where R is an aliphatic group having 1 to 30 carbons) with dicarboxylic acids, such as, for example, malonic, succinic, glutaric or adipic acid, to yield  $-(\text{CH}_2)_m-(\text{CO})-\text{O}-\text{R}$ , where  $m = 1$  to 4. These resulting malonyl, succinyl, glutaryl or 25 adipoyl fatty groups are, structurally, aliphatic fatty alcohols with their chains extended by the radicals  $-\text{OC}-\text{CH}_2-\text{CO}-$  (malonyl),  $-\text{OC}-(\text{CH}_2)_2-\text{CO}-$  (succinyl),  $-\text{OC}-(\text{CH}_2)_3-\text{CO}-$  (glutaryl),  $-\text{OC}-(\text{CH}_2)_4-\text{CO}-$  (adipoyl), and the like. Thus, where a fatty alcohol is denoted by  $\text{ROH}$ , a malonyl- (or malonate-extended) fatty group would be  $\text{R}-\text{O}-(\text{CO})-\text{CH}_2-(\text{CO})-$ , a succinyl- (or succinate-extended) fatty group would be  $\text{R}-\text{O}-(\text{CO})-(\text{CH}_2)_2-(\text{CO})-$ , a glutaryl- (or glutarate-extended) fatty group would be  $\text{R}-\text{O}-(\text{CO})-(\text{CH}_2)_3-(\text{CO})-$ , and so forth.

30 At least one  $\text{F}_i$  will have 8 or more carbons, and the remainder will be selected to provide a discernible fatty character in the compounds. Many of the F groups will have 3 or more carbon atoms, with a percentage containing 3 to 23, more narrowly 10 to 20, and even more narrowly, 15 to 18 carbon atoms. Where the fatty groups are fatty acid or alcohol groups derived from natural oils, for example, safflower, sunflower, corn or soybean oil, 98% or more of the groups are derived from fatty acids containing 16 to 18 35 carbon atoms, with 80% or more containing 18 carbon atoms.

The ester groups or dicarboxylate-extended ester groups are attached to one end or terminus, as described in the generalized formula, *supra*, either in vicinal relation to one another, or separated by one or two methylene groups. In these positions, the diol can be said to be "terminally esterified."

40 The preferred long chain diol diesters of this invention are partially digestible, and providing from about 0.5 to 8.5 kcal/gram, more narrowly 1.0 to 6.0 kcal/gram. In these preferred compounds, the fatty groups show differential reactivity toward enzymatic hydrolysis, so that the compounds become more hydrophilic when catabolized. The cleaved residue can be an essential or nutritionally desirable fatty acid such as linoleic acid. The cleaved residue can also be a fatty acid with preventative or possible curative effects for certain diseases or conditions, such as, for example, a conjugated linoleic acid.

45 The ester compounds of this invention may be prepared using standard esterification techniques for diols (reviewed in Markley, K.S., *Fatty Acids*, 2nd ed., part 2, Krieger Pub. Co., 1983, pp. 785-797 and used in preparing long chain derivatives by Marosi, L., and Schlenk, W., *Liebigs Ann. Chem.* 1973 584). These include reactions of the fatty acids, acid chlorides or anhydrides with the diols, or transesterification between fatty acid esters (e.g., fatty acid methyl esters) and alcohols.

50 The dicarboxylate-extended fatty acid diester compounds of this invention may be prepared by reacting the fatty alcohols or fatty alcohol derivatives with the dicarboxylic acids, and then reacting the fatty acid-dicarboxylic acid adducts with the diols.

55 A solvent may be employed in the syntheses. The term "solvent" means any material, including the reactants, that is liquid at the synthesis reaction temperature and pressure and will dissolve, suspend or hold the reactants in the reaction mixture in an amount effective to expedite contact for the desired esterification reaction to occur.

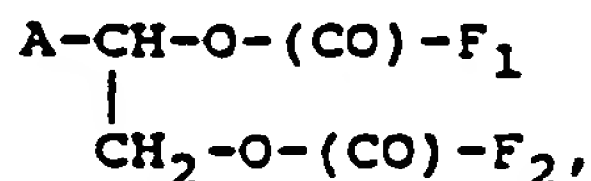
The long chain diol esters of this invention may be incorporated either alone, or in combination with another fat (for example, admixed with a triglyceride oil) and/or fat mimetic, into any food composition or

used in conjunction with any edible material. The term "edible material" is broad and includes anything edible. Representative of edible materials which can contain the long chain diol diesters of this invention in full or partial replacement of natural fat are: frozen desserts, e.g., sherbet, ice cream, ices, or milk shakes; puddings and pie fillings; margarine substitutes or blends; flavored bread or biscuit spreads; mayonnaise; 5 salad dressings; filled dairy products such as filled cream or filled milk; dairy or non-dairy cheese spreads; coffee lighteners, liquid and dried; flavored dips; frying fats and oils; reformed and comminuted meats; meat substitutes or extenders; whipped toppings; compound coatings; frostings and fillings; cocoa butter replacements or blends; candy, especially fatty candies such as those containing peanut butter or chocolate; chewing gum; bakery products, e.g., cakes, breads, rolls, pastries, cookies, biscuits, and savory 10 crackers; mixes or ingredient premixes for any of these; as well as flavor, nutrient, drug or functional additive delivery systems.

The following is a list of representative, but not limiting, examples of long chain diol lipids of this invention:

(A) Diol diesters with vicinal groups at the terminus of an aliphatic chain having the general formula:

15



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where

A is an aliphatic chain having 9 to 28 carbons, and  $\text{F}_1$  and  $\text{F}_2$  are aliphatic groups having 1 to 30 carbon atoms,

or carboxylate-extended groups of the formula

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$-(\text{CH}_2)_m-(\text{CO})-\text{O}-\text{R}$ , with  $m = 1$  to 4,

and R having 1 to 30 carbon atoms.

Examples of this type of long chain diol esters include

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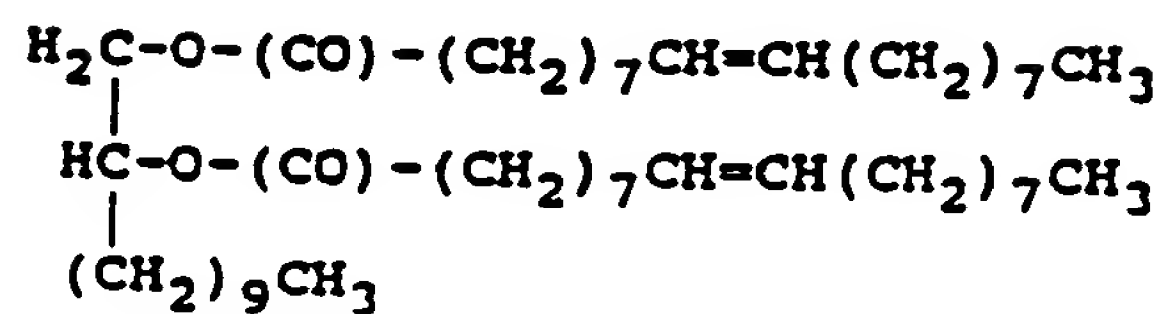
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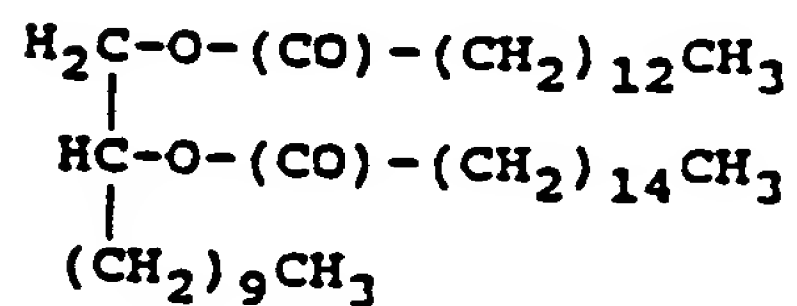
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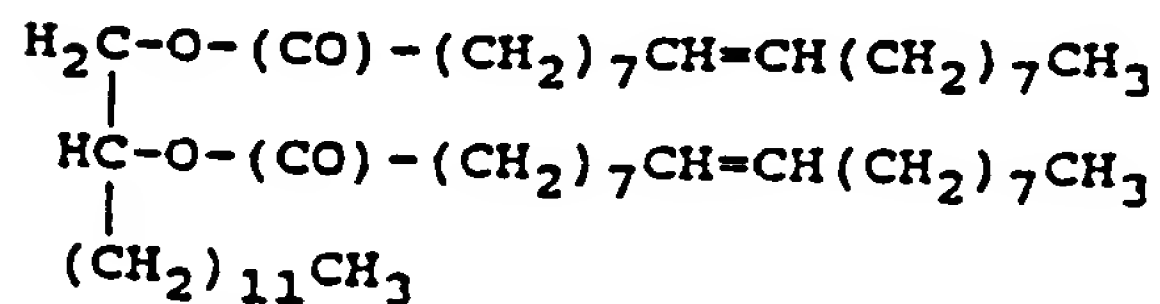
## (1) 1,2-Dodecane Dioleate



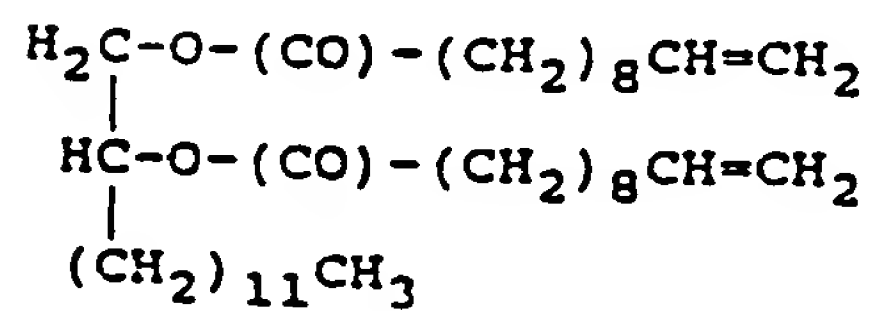
## (2) Tetradecane 1-Myristate-2-palmitate



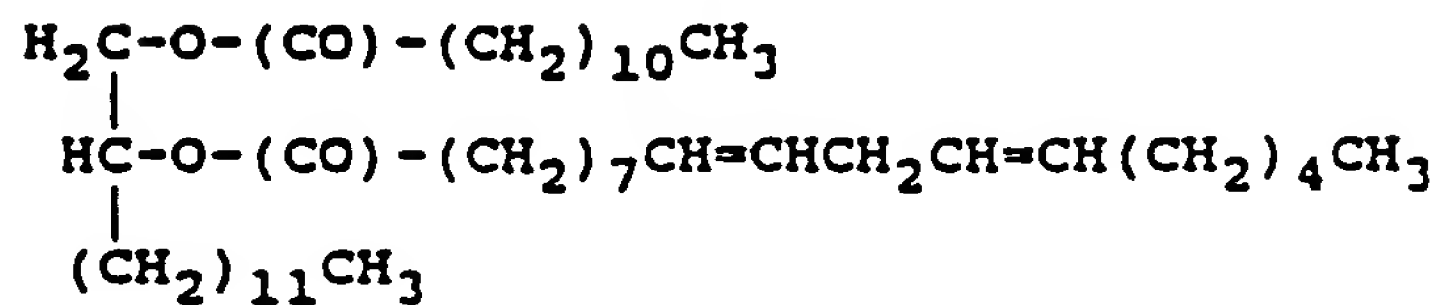
## (3) 1,2-Tetradecane Dioleate



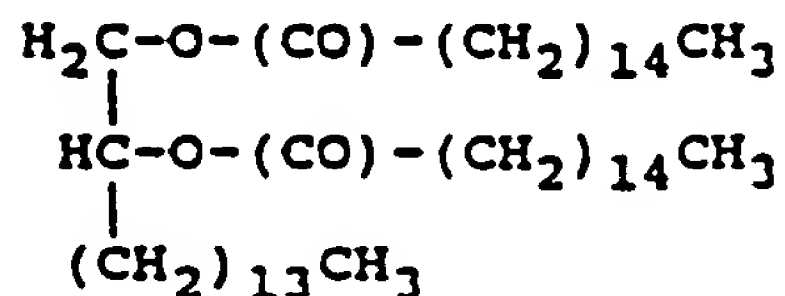
## (4) 1,2-Tetradecane Di-10-undecenate



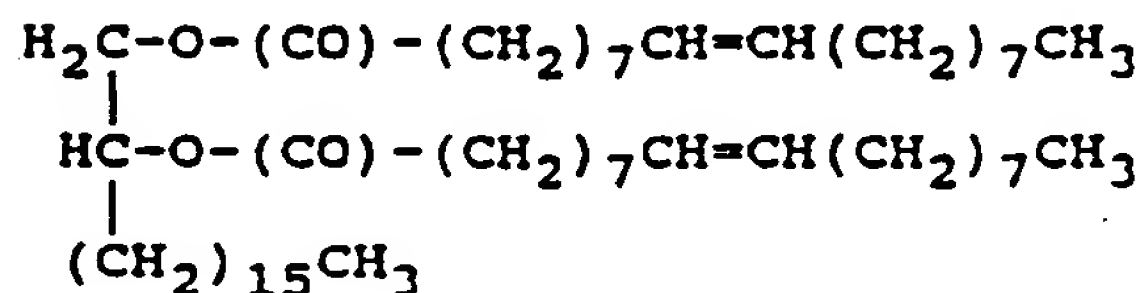
## (5) Tetradecane 1-Laurate-2-Linoleate



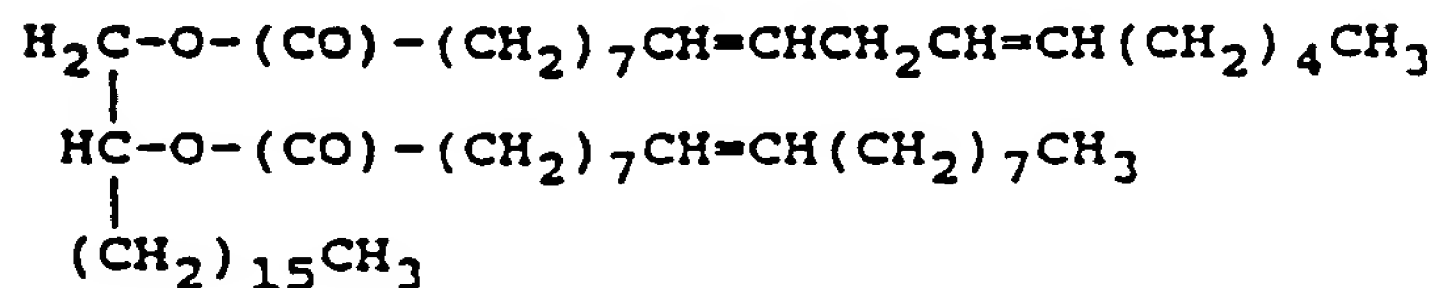
## (6) 1,2-Hexadecane Dipalmitate



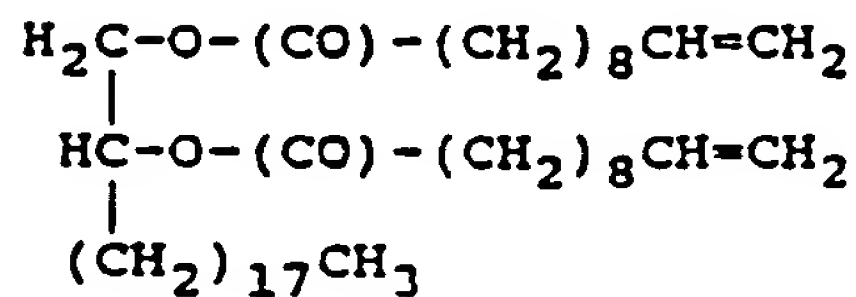
## (7) 1,2-Octadecane Dioleate



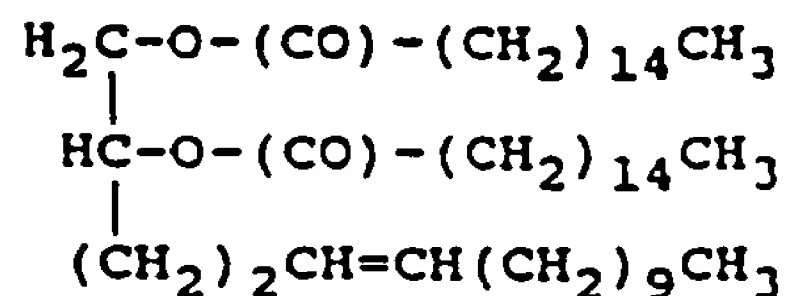
## (8) Octadecane 1-Linoleate-2-oleate



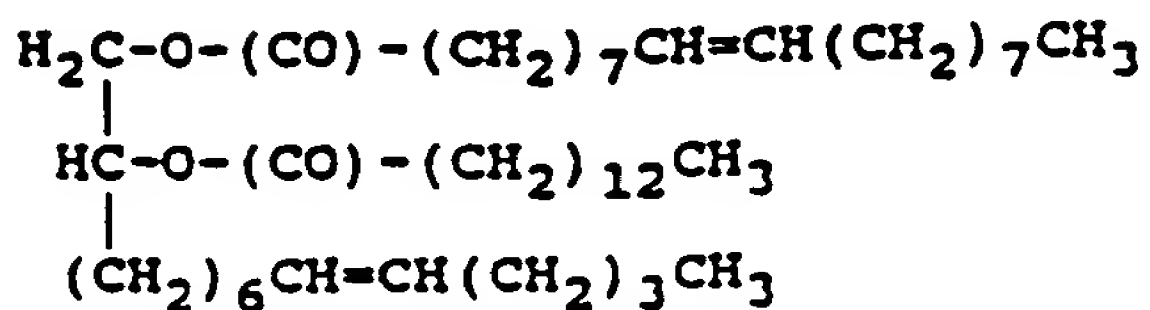
## (9) 1,2-Icosane Di-10-undecenatate



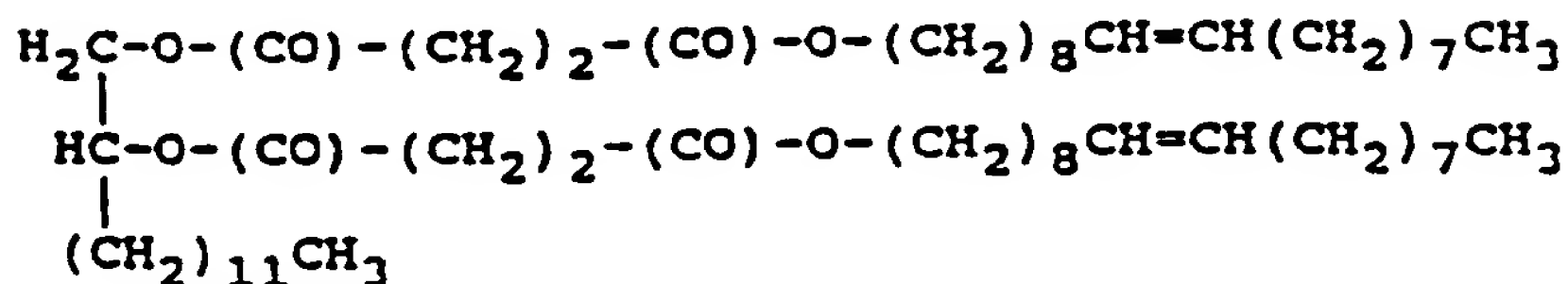
## (10) 1,2-Hexadec-5-ene Dipalmitate



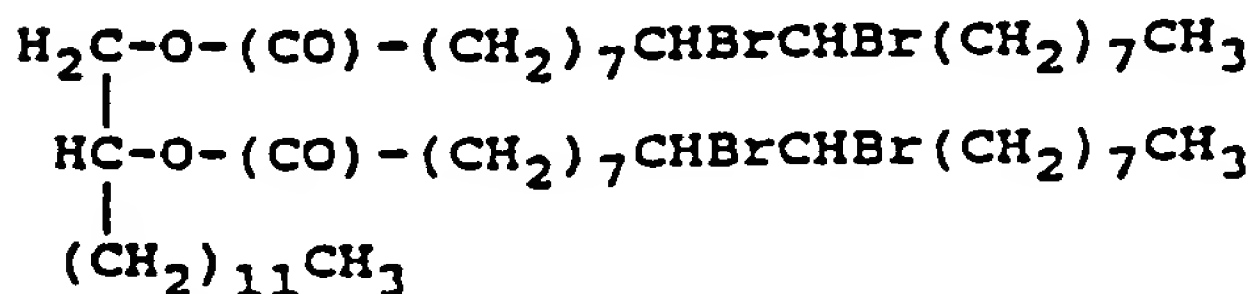
## (11) Tetradec-9-ene 1-Oleate-2-myristate



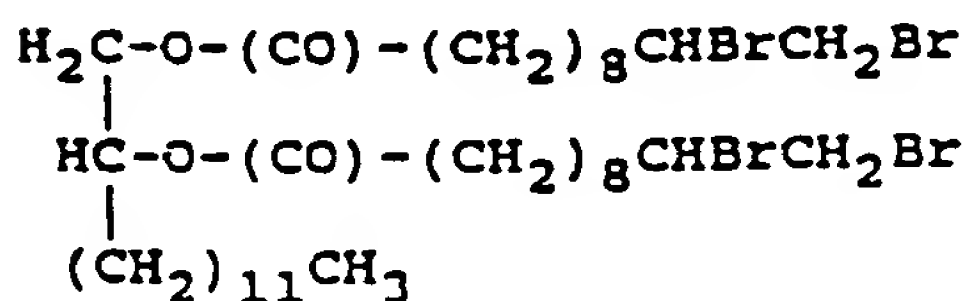
## (12) Tetradecane Disuccinyloleate



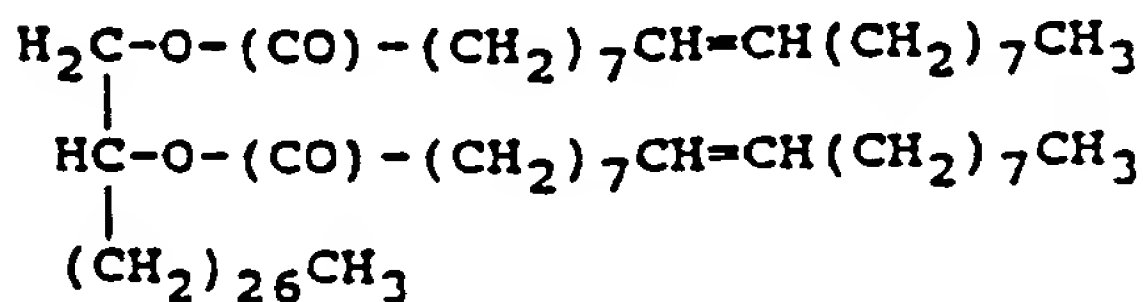
## (13) Tetradecane Dibromooleate



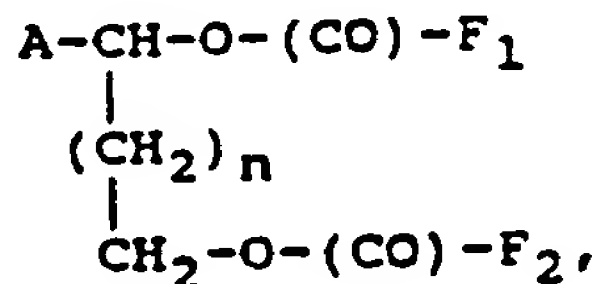
## (14) 1,2-Tetradecane Dibromo-10-undecenate



## (15) 1,2-Montanyl Dioleate



(B) Diol diesters with the ester groups separated by one or two methylene groups having the general formula:



where

$n = 1$  or  $2$ .

A is an aliphatic chain having 8 to 27 carbons.

$F_1$  and  $F_2$  are aliphatic groups having 1 to 30 carbon atoms,

5 or carboxylate-extended groups of the formula.

$-(CH_2)_m-(CO)-O-R$ , with  $m = 1$  to  $4$ ,

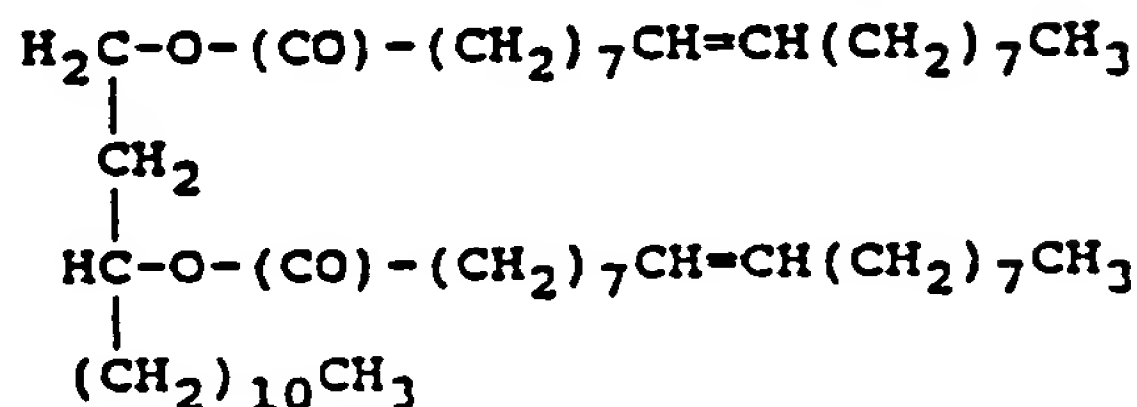
and R having 1 to 30 carbon atoms.

Examples of this type of long chain diol diesters include:

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(16) 1,3-Tetradecane Dioleate

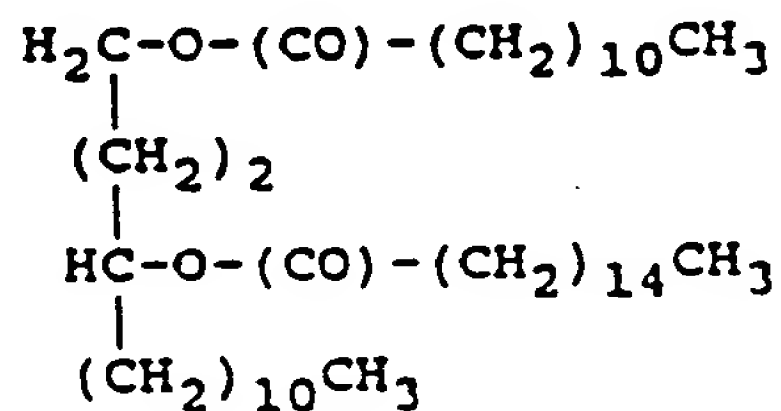
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(17) Pentadecane 1-Laurate-4-palmitate

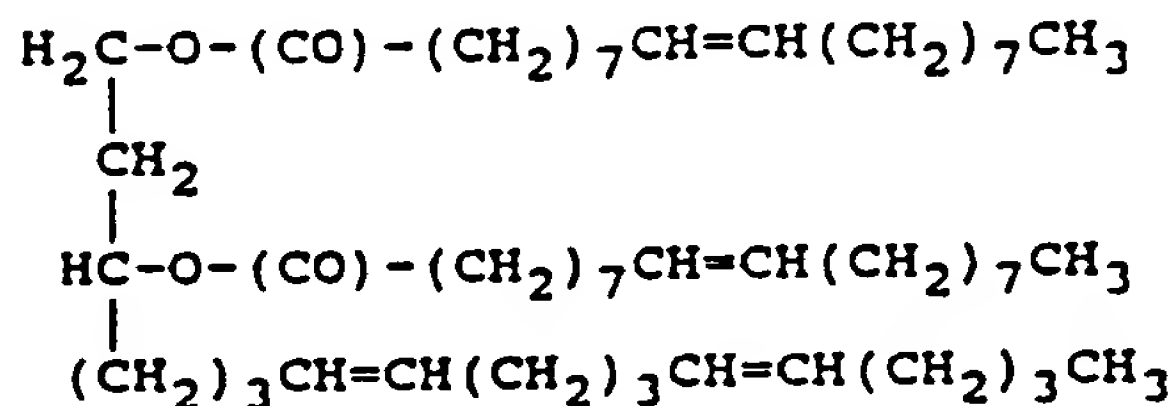
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(18) 1,3-Heptadec-7,12-diene Dioleate

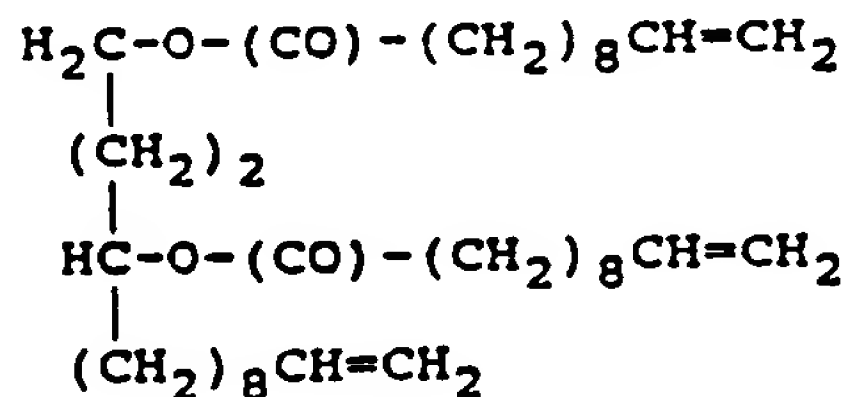
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(19) 1,4-Tetradec-13-ene Di-10-undecenate

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EXAMPLES

The following examples are presented to further illustrate and explain the present invention and should not be taken as limiting in any regard. Unless otherwise indicated, all parts and percentages (in both the chemical syntheses and food recipes) are by weight, and are based on the weight at the particular stage of the processing being described. The proton NMR spectra have assigned chemical shifts, multiplicities, and intensities consistent with the structures for which they are reported.

#### Example 1

1,2 Tetradecane dioleate (also called 1,2-*bis* (oleoyl-oxy) tetradecane), a diol lipid analogue of this invention, is prepared in this example.

A 5-liter round bottom flask is charged with 414 grams (1.8 moles) 1,2-tetradecanediol and 1.5 liters pyridine. The flask contents are stirred by means of a mechanical stirrer to produce a solution. To this is added 1260 mL (ca. 3.8 moles) oleoyl chloride in five portions with vigorous stirring. The reaction is exothermic and produces a white precipitate. After cooling at room temperature (1.75 hours), the mixture is suction filtered through a Buchner funnel and the solid pyridinium chloride is washed with three 50-mL portions of hexane. The filtrate is concentrated by means of a vacuum rotary evaporator (ca. 100 torr) at 100° C., and then is suction filtered through 500 grams of chromatographic grade silica.

The filtrate is decolorized with ca. 5 wt % activated carbon and given a final filtration through 150 grams silica. The resulting oil is diluted with 1/3 volume of hexane and washed with 5% HCl (800 mL), dried over anhydrous sodium sulfate and magnesium sulfate, and finally filtered and concentrated by rotary evaporation. The residue is passed through a falling film still (168° C., ca. 1 torr) and steam deodorized (200° C., 1 torr) with ca. 5 wt % water to afford 900 grams (67%) of the title composition as a clear, amber colored oil.

Proton NMR Spectrum in CDCl<sub>3</sub>: chemical shift in ppm (multiplicity; intensity; assignment): 5.32 (multiplet; 4 H; HC=CH), 5.08 (apparent quartet of doublets  $J = 7.0, 7.0, 6.3$  and  $4.2$  Hz; 1 H; methine proton), 4.22 (doublet of doublets,  $J = 13.0$  and  $4.2$  Hz, 1 H, one half of -CH<sub>2</sub>-O), 4.04 (doublet of doublets,  $J = 13.0$  and  $6.3$  Hz, 1 H, one half of -CH<sub>2</sub>-O), 2.30 (triplet; 4 H, O=C-CH<sub>2</sub>), 2.01 (multiplet; 8 H, C=C-CH<sub>2</sub>), 1.60 (broad multiplet, 6 H, O=C-C-CH<sub>2</sub> and O-C-CH<sub>2</sub>), 1.30 (multiplet; 60 H, -CH<sub>2</sub>-) and 0.87 (triplet, 9 H, -CH<sub>3</sub>).

#### Example 2

1,2-Dodecane dioleate (also called 1,2-*bis*(*cis*-9-octadecenoyloxy)dodecane, another long chain diol diester of this invention, is prepared in this example.

To a solution of 2.02 g, (0.01 mole) dodecane-1,2-diol in 20 mL pyridine is added 6.66 mL (0.02 mole) oleoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated, and refiltered to afford a yellow oil.

#### Example 3

1,2-Tetradecane di-10-undecenate (also called 1,2-*bis*-(10-undecenoyloxy)tetradecane), another long chain diol diester of this invention, is prepared in this example.

To a solution of 2.30 g, (0.01 mole) tetradecane-1,2-diol in 20 mL pyridine is added 4.04 g (0.02 mole) 10-undecenoyl chloride. The reaction mixture is shaken at ambient temperature overnight, filtered, concentrated and refiltered to afford an oil.

#### Example 4

1,2-Tetradecane dibromodi-10-undecenate (also called 1-2-*bis*(9,10-dibromoundecanoyloxy)tetradecane) is prepared in this example.

1,2-*Bis*-(10-undecenoyloxy)-tetradecane (2.0 g, 0.0026 mole, prepared in Example 3) is treated with 5% bromine in carbon tetrachloride (25 mL). After 5 minutes, the volatiles are removed on the rotary evaporator

to afford an oil.

Proton NMR spectrum in chloroform-d: chemical shift in ppm (multiplicity, intensity, assignment): 5.08 (apparent octet, 1 H, methine proton), 4.22 (doublet of doublets, 1 H, one half of CH<sub>2</sub>-O<sub>2</sub>C), 4.15 (multiplet, 2 H, CHBr), 4.02 (doublet of doublets, 1 H, one half of CH<sub>2</sub>-O<sub>2</sub>C), 3.85 (doublet of doublets, 2 H, CH<sub>2</sub>Br), 3.62 (triplet, 2 H, CH<sub>2</sub>Br), 2.31 (triplet, 4 H, O<sub>2</sub>C-CH<sub>2</sub>), 2.12 (multiplet, 2 H, CH<sub>2</sub>-C-Br), 1.77 (multiplet, 2 H, CH<sub>2</sub>-C-Br), 1.3-1.6 (multiplet, 46 H, CH<sub>2</sub>) and 0.87 (triplet, 3 H, CH<sub>3</sub>).

#### Example 5

10

Tetradecane disuccinylolate (also called 1,2-*bis*-5-oxa-4-oxotricos-14-enoyloxy)tetradecane) is prepared in this example.

To a solution of 2.30 g (0.01 mole) tetradecane-1,2-diol in 20 mL pyridine is added 7.73 g (0.02 mole) *cis*-5-oxa-4-oxotricos-14-enoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated, and refiltered to afford a yellow oil.

#### Example 6

20

1,2-Tetradecane dimyristate (also called 1,*bis*(myristoyloxy) tetradecane), another long chain diol diester of this invention, is prepared in this example.

To a solution of tetradecane-1,2-diol (2.30 g, 0.01 mole) in 20 mL pyridine is added myristoyl chloride (4.92 g, 0.02 mole). The reaction mixture is shaken at ambient temperature overnight, filtered, concentrated and refiltered to afford an oil. The oil is taken up in ether and washed with 5% HCl twice, 5% NaHCO<sub>3</sub> once, and brine once, dried over sodium sulfate and concentrated on the rotary evaporator (95 °C, ca. 100 torr).

30

#### Example 7

1,2-Hexadecane dioleate (also called 1,2-*bis*(*cis*-9-octadecenoyloxy)hexadecane) is prepared in this example.

To a solution of 2.58 g, 0.01 mole) hexadecane-1,2-diol in 20 mL pyridine is added 6.66 mL (0.02 mole) oleoyl chloride. The reaction mixture is shaken at ambient temperature overnight, filtered, concentrated and refiltered to afford an oil.

40

#### Example 8

1,2-Hexadecane dilaurate (also called 1,2-*bis*(do-decanoyloxy)hexadecane) is prepared in this example.

To a solution of 2.58 g (0.01 mole) of 1,2-hexadecane-diol in 20 mL pyridine is added 4.38 g (0.02 mole) of lauroyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

50

#### Example 9

1,2-Hexadecane dimyristate (also called 1,2-*bis* (tetradecanoyloxy)hexadecane) is synthesized in this example.

To a solution of 2.58 g (0.01 mole) of 1,2-hexadecane-diol in 20 mL pyridine is added 4.94 g (0.02 mole) of myristoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 10

1,2-Hexadecane distearate (also called 1,2-*bis* (octadecanoyloxy)hexadecane) is prepared in this example.

To a solution of 2.58 g (0.01 mole) of 1,2-hexadecane-diol in 20 mL pyridine is added 6.06 g (0.02 mole) of stearoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 11

1,2-Hexadecane di-10-undecenate (also called 1,2-*bis* (10-undecenoyloxy)hexadecane) is prepared in this example.

To a solution of 2.58 g (0.01 mole) of 1,2-hexadecane-diol in 20 mL pyridine is added 4.04 g (0.02 mole) of 10-undecenoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 12

1,2-Hexadecane dipalmitate (also called 1,2-*bis*(hexadecanoyloxy)hexadecane) is prepared in this example.

To a solution of 2.58 g (0.01 mole) of 1,2-hexadecane-diol in 20 mL pyridine is added 5.50 g (0.02 mole) of palmitoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 13

1,2-Tetradecane dilaurate (also called 1,2-*bis* (dodecanoyloxy)tetradecane) is synthesized in this example.

To a solution of 2.30 g (0.01 mole) of 1,2-tetradecane-diol in 20 mL pyridine is added 4.38 g (0.02 mole) of lauroyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 14

1,2-Tetradecane distearate (also called 1,2-*bis*-(octadecanoyloxy)tetradecane, another long chain diol diester of this invention, is prepared in this example.

To a solution of 2.30 g (0.01 mole) of 1,2-tetradecane-diol in 20 mL pyridine is added 6.06 g (0.02 mole) of stearoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 15

1,2-Tetradecane dipalmitate (also called 1,2-*bis* (hexadecanoyloxy)tetradecane) is prepared in this example.

To a solution of 2.30 g (0.01 mole) of 1,2-tetradecane-diol in 20 mL pyridine is added 5.50 (0.02 mole) of palmitoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

Example 16

1,2-Dodecane dimyristate (also called 1,2-*bis* (tetradecanoyloxy)dodecane) is prepared in this example.

To a solution of 2.02 g (0.01 mole) of 1,2-dodecanediol in 20 mL pyridine is added 4.94 g (0.01 mole) of myristoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

#### Example 17

1,2-Dodecane di-10-undecenate (also called 1,2-*bis* (10-undecenoyloxy)dodecane) is prepared in this example.

To a solution of 2.02 g (0.01 mole) of 1,2-dodecanediol in 20 mL pyridine is added 4.04 g (0.02 mole) of 10-undecenoyl chloride. The reaction mixture is shaken overnight at ambient temperature, filtered, concentrated and refiltered through silica to afford the title compound.

#### Example 18

Tetradecane dibromooleate (also called 1,2-*bis* (9,10-dibromooctadecenoyloxy)tetradecane) is prepared in this example.

1,2-*Bis*(*cis*-9-dibromo-octadecenoyloxy)tetradecane (1.89 g, 0.0025 mole) is treated with a solution of 5 % bromine in carbon tetrachloride (25 mL). After 5 minutes, the volatiles are removed on the rotary evaporator to afford a yellow oil.

#### Example 19

This example outlines the procedure for estimating the *in vitro* digestibility of the long chain diol diesters of this invention.

#### Preparation of Reagents and Materials:

1. Buffer: A pH 7.1 phosphate buffer is prepared by dissolving 6.8 g.  $\text{KH}_2\text{PO}_4$  in 1 L. of millipore filtered water (to yield 0.05 M phosphate). Fifty mg.  $\text{Ca}(\text{NO}_3)_2$  and 5.0 g. cholic acid (Na salt, an ox bile isolate from Sigma) are added to give 300 microM  $\text{Ca}^{++}$  and 0.5 % cholic acid in 0.05 M phosphate. The pH is adjusted to approximately 7.1 with solid NaOH. Several drops of Baker "Resi-analyzed" toluene are added to prevent bacterial growth during storage at 3-5° C.

2. Lipase: About 15 mg./mL commercial porcine pancreatic lipase from U.S. Biochemical Corporation is dissolved in buffer.

3. Substrates and Standards: A 1.0 mL volumetric flask is charged with an amount of lipid substrate calculated to give a concentration of 200 nanomoles per microliter in Baker "Resi-analyzed" toluene. (The proper concentration may be approximated by doubling the molecular weight of the lipid in question, dividing by 10, and diluting to the mark; this yields about 200 nanomoles per microliter.) This preparation affords the substrate to be used in the hydrolysis reactions.

Fatty acids and glyceride standards from Nu Chek or Sigma are prepared for elution on thin layer chromatography (TLC) plates (prewashed with 1:1 chloroform/methanol) by diluting the substrate solution with 10:1 toluene (1 part substrate plus 9 parts toluene) in septum vials.

#### Procedure:

In a 25 mL Erlenmeyer, emulsify 20 mL buffer and 40 microliters of substrate using an ultrasonic disrupter at a microtip maximum setting for approximately 10 seconds. This results in a 0.4

microliter/milliliter emulsion. Place in a 37° C. water bath and stir vigorously. After temperature equilibration, add 40 microliters of enzyme solution and start timing. Remove 5.0 mL aliquots at convenient time intervals for analysis. To establish a standard curve for triolein, aliquots are taken at 10, 20, 30 and 40 minutes. A zero time control should be run for all test compounds.

5 Add the aliquot to a 15 mL glass centrifuge tube containing a drop of concentrated HCl. Add approximately 3 mL of a 2:1 mixture of  $\text{CHCl}_3$ : $\text{CH}_3\text{OH}$  and shake vigorously. Centrifuge at approximately 5000 rpm for 5 minutes and transfer the bottom layer with a Pasteur pipet to a 5 mL septum vial. Repeat the extraction step once and combine the two bottom layers. Evaporate the solvent in nitrogen gas. After about half of the solvent is removed, add an equivalent volume absolute ethanol and continue evaporation in  
10 a nitrogen stream until dryness is achieved. Samples may be warmed with a heat gun to facilitate drying.

When the samples are dry, add exactly 200 microliters of toluene containing 10% DMSO, cap tightly, and spot TLC plate with 2.0 microliters per channel. (If 100% extraction efficiency of a zero time control, this amounts to 20 nanomoles of substrate spotted on the plate.) Develop with a suitable solvent system, for example, hexane: ethyl ether: acetic acid in a ratio of 60:40:1. After 15 cm elution, dry plate with a heat gun  
15 and determine amounts of starting substrate and products of hydrolysis by scanning 10 to 20 nanomoles per channel at a wavelength of 190 nm using a CAMAG TLC Scanner II densitometer equipped with a Spectra Physics 4270 integrator and comparing with controls run at the same time.

## 20 Results:

Using this procedure and enzyme system, triolein, a triglyceride control, is substantially hydrolyzed in 10 minutes. Under the same conditions, 1,2-tetradecane dioleate, a long chain diol diester of this invention prepared in Example 1, is approximately 20% hydrolyzed in three hours.

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## Example 20

30 This example illustrates how the novel fat mimetics of this invention are screened for caloric availability by a carefully controlled *in vivo* animal feeding study.

An experimental relationship between total calories ingested and animal body weight gain is established by monitoring the body weight gain associated with consumption of a nutritionally balanced diet containing varying concentrations of a reference substance such as corn oil which has a known caloric availability.  
35 Correlations between total calories ingested and body weight gain are excellent ( $r = 0.99$ ).

Caloric availability of an unknown substance is evaluated by substituting a specific weight of the unknown substance for the reference substance and observing the body weight gain. The gain in body weight is equated to a total number of calories using the correlation previously established for the reference data. The estimated number of calories ingested are divided by the weight of unknown substance to give  
40 the apparent calories per gram for the unknown substance. Generally speaking, in these bioavailability studies, the degree of perianal pelt soiling correlates with reduced bioavailability.

The test animals are six-week-old male Sprague-Dawley rats obtained from the Portage, Michigan facility of the Charles River Laboratories, Inc. After acclimation for 15 days, the test duration is 14 days. The dietary requirements are established by observing the actual feed consumption of animals provided with  
45 unlimited feed. All diets are prepared to contain 50% of the established dietary requirements plus any supplements of reference or unknown substances. In all tests so designed the test animals are maintained in very good health.

The test feeds are AIN-76A and fortified AIN-76A (hereinafter abbreviated "fort") AIN-76A (Teklad). The major components of these diets are as follows:

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component	AIN-76A	fortified AIN-76A
casein	20%	40%
corn starch	15	8.08
sucrose	50	26.02
fiber	5	5
corn oil	5	5
AIN mineral mix	3.5	7
AIN vitamin mix	1	2
choline	0.2	0.4
methionine	0.3	0.6
total	100%	100%
calc. caloric density	3.85 kcal/gm	3.9 kcal/gm

Using these diets supplemented by reference or unknown substances fed as microencapsulated oils, sample body weight (hereinafter abbreviated "wgt") gains for example animals A and B fed corn oil as a reference (9.0 calories/gram) are as follows:

diet supplied	Animal A		Animal B	
	wgt gain (grams)	calories consumed	wgt gain (grams)	calories consumed
<i>ad lib</i> AIN-76A	73.6	1275	82.4	1370
50% fort	-3.4	651	-3.8	691
50% fort + 7.75% gelatin	9.0	705	8.3	747
50% fort + 7% corn oil	13.9	768	15.2	831
50% fort + 14% corn oil	28.3	913	37.9	998
50% fort + 21% corn oil	57.7	1093	63.3	1183

Rats were fed a diet of 50% fort and 21% 1,2-tetradecane dioleate prepared in Example 1 as a test compound under the foregoing procedure, and their weight gain was determined. Based upon the base line control data, and the data from the test compound, it was determined that 1,2-tetradecane dioleate gave about 6.0 kcal/gram upon being metabolized.

#### Example 21

Sweet Chocolate . A low calorie sweet chocolate may be prepared by combining:

Ingredient	parts
Cocoa Powder	1.0
Sugar	1.0
To this is added a portion of	
Diol Diester of Example 8	1.0

and the ingredients are mixed thoroughly and passed through a refiner to reduce the particles to desired size. The material is conched, and the remaining diol diester is added. The mixture is poured into molds and quench cooled. No tempering regimen is necessary.

Chocolate Chips . The chocolate prepared above may be melted and deposited into nibs in the usual process.

Example 22

Sugar Cookies . Sugar cookies may be prepared by blending:

<u>Ingredient</u>	<u>parts</u>
Sugar	231
Example 1 Diol Diester	114
Salt	3.7
Sodium Bicarbonate	4.4
Water	37.4
5.9% Dextrose Solution (wt/wt)	58.7
Flour	391

All of the ingredients are creamed together. The dough so formed may be extruded (the dough is very tacky) and baked by the usual process.

Example 23

Margarine . Margarine may be prepared by combining the ingredients for the following two phases:

<u>Oil Phase Ingredients</u>	<u>parts</u>
Example 2 Diol Diester	59.0
Soybean Hardstock (IV 65)	40.0
Emulsifier	1.0
<u>Aqueous Phase Ingredients</u>	
Water	95.8
Milk Solids	2.0
Salt	2.0
Citric Acid	0.1
Beta Carotene	0.1

The phases are emulsified in an oil:aqueous phase ratio of 80:20, and passed through a cool scraped surface heat exchanger in the usual process.

Example 24

Flavor Bits . Flavor bits for incorporation into baked goods may be prepared by combining the following ingredients:

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<u>Ingredient</u>	<u>parts</u>
Sucrose	215
Water	180
Corn Syrup	160
Example 23 Margarine	28
Flavor	12
Citric Acid	10
Glycerine	8
Salt	5
Dye	1

15

The first three ingredients are heated to 290° F. and the heat removed. Margarine is mixed in, and the mixture allowed to cool to 160-170° F. before adding the remaining ingredients. (Almost any flavoring material may be used as flavor, for example, butterscotch or nut.) The mixture is then poured into a cold aluminum pan and frozen in dry ice. The frozen mixture is then cracked and milled into bits.

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#### Example 25

Butterscotch Cookies . Butterscotch cookies may be prepared by blending:

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<u>Ingredient</u>	<u>parts</u>
Flour	22.0
Example 6 Diol Diester	20.0
Salt	0.7
Sodium Bicarbonate	0.1
Monocalcium Phosphate	0.1
Vanillin	0.1
Water	8.0
and mixing well. To this is added	
Sugar	30.0
which is mixed until dispersed. Then	
Example 25 Butterscotch Bits	19.0
are added and mixed until just blended prior to depositing and baking in the usual process.	

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Vanilla Wafers . To prepare vanilla wafers, blend:

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<u>Ingredient</u>	<u>parts</u>
Example 12 Diol Diester	25
Flour	100
Granulated Sugar	72
High Fructose Corn Syrup	5.0
Nonfat Dry Milk	1.0
Salt	1.0
Ammonium Bicarbonate	0.1
Dried Egg Yolk	1.0
Water	55

The dough so formed may be rolled, wire cut to 1/4 inch thickness, and baked by the usual process to give a vanilla wafer cookie.

#### Example 27

Chocolate chip Cookies . Chocolate chip cookies may be prepared using the butterscotch cookie recipe of Example 25, but substituting

<u>Ingredient</u>	<u>parts</u>
Example 23 Margarine	10.0
Example 15 Diol Diester	10.0
for the fat mimetic ingredient,	
Granulated Sugar	15.0
Brown Sugar	15.0
for the sugar, and	
Example 21 Chocolate Chips	19.0
for the butterscotch bits.	

#### Example 28

Filled Cream . To make a "filled cream" composition, homogenize about

<u>Ingredient</u>	<u>parts</u>
Example 3 Diol Diester	30
Skim Milk	82
Polysorbate 80	0.1

in a conventional dairy homogenizer.

#### Example 29

Ice Cream . Vanilla ice cream may be prepared by mixing

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<u>Ingredient</u>	<u>parts</u>
Sugar (10X)	15.0
Nonfat Dry Milk	3.9
Salt	0.4
into Water	39.0
for 3 minutes. Then add melted	
Example 8 Diol Diester	28.4
and cook to 200° F while mixing. Hold for 1 minute. Cool to 160° F., and add	
Sugared Egg Yolks	12.5
Vanilla Extract	0.8
and mix 1 minute. Fill, then cool and freeze.	

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Example 30

Filled Milk . To prepare a "filled milk" composition, combine about

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<u>Ingredient</u>	<u>parts</u>
Example 28 Filled Cream	100
Skim Milk	900

35

and rehomogenize.

40

Example 31

Cheese Products . To prepare cheese products, treat  
Ingredient

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Example 30 Filled Milk

made with a 1:1 mixture of Examples 10 and 11 long chain diol diesters like natural milk in the normal cheese making process (as is practiced, for example in the production of cheddar or swiss cheese). Preferably add

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	<u>parts</u>
Butter Oil	10

55 to the diol diester portion of the filled milk product before it is employed in this process to enhance the proper flavor development of the cheese products.

Example 32

Butter Cream Icing . Butter cream icing may be prepared by blending:

<u>Ingredient</u>	<u>parts</u>
Sugar	227.0
Example 13 Diol Diester	70.8
Water	28.4
Nonfat Dry Milk	14.0
Emulsifier	1.4
Salt	1.0
Vanilla	1.0

All of the ingredients are creamed in a mixer at medium speed.

Example 33

Crackers . A dough prepared by mixing together

<u>Ingredient</u>	<u>parts</u>
Flour	100
Sugar	5.0
Malt	1.5
Example 17 Diol Diester	7.5
Salt	1.0
Sodium Bicarbonate	0.9
Nonfat Dry Milk	2.5
High Fructose Corn Syrup	2.5
Monocalcium Phosphate	0.75
Water	28

is sheeted, stamped, and baked to produce a cracker product.

Example 34

Sprayed Crackers . The sheeted and stamped cracker dough of Example 33 may be sprayed with the diol diester of Example 1 after baking.

Example 35

Mayonnaise . Mayonnaise can be prepared from the following formulation:

<u>Ingredient</u>	<u>parts</u>
Example 2 Diol Diester	80
Egg yolk	5.5
Vinegar	3.0
Salt	1.5
Sugar	2.0
Flavor	0.5
Water	7.5

The egg yolk is first mixed with the other dry ingredients and a small amount of the water and vinegar in a container. The diester is then slowly poured into the container, while subjecting the container contents to mixing, to form an emulsion. While continuing to agitate the emulsion, the remaining water and vinegar is added.

#### Example 36

Pudding . Pudding can be prepared from the following formulation:

<u>Ingredient</u>	<u>parts</u>
Milk	67
Sugar	11
Starch	5
Water	9
Flavor	3
Example 3 Diol Diester	5

The ingredients can be blended together to form a pudding.

#### Example 37

Frying Oil . The diol diester of Example 7 with 1 ppm polydimethylsiloxane may be used for frying food snacks. For frying potatoes, the polydimethylsiloxane may be omitted.

#### Example 38

Pet Food . Dry, expanded animal food kibs may be prepared from the following ingredients:

<u>Ingredient</u>	<u>parts</u>
Hominy Feed	37
52% Meat Meal	17
Wheat Shorts	13
Example 16 Diol Diester	16
Corn Germ Meal	9.6
Wheat Germ Meal	3
Dried Milk	0.9
Beet Pulp	1.7
Fish Scrap	0.5
Brewer's Yeast	0.5
Salt	0.5
Vitamins and Minerals	0.1

The ingredients are mixed together and water added to raise the water content to 27%, before extrusion, pelleting, and drying in the usual manner.

#### Example 39

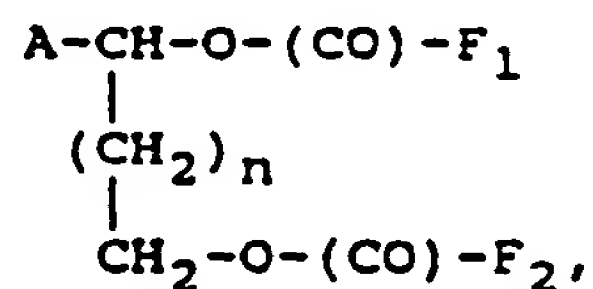
Semi-Dilute Beverage Clouding Agent Concentrate . A semi-diluted beverage concentrate may be prepared by emulsifying:

<u>Ingredient</u>	<u>parts</u>
Water	63.25
Potassium Sorbate	0.03
Xanthan Gum	0.50
Sucrose	5.25
Citric Acid	0.024
Polyglycerol Ester	0.90
Propylene Glycol Ester	0.90
Diol Diester of Example 4	21.8
Diol Diester of Example 9	5.4
Milk Protein	1.9
Powdered Vanilla	0.15
Flavorings	0.05

The resulting emulsion is a viscous liquid which may be mixed in a ratio of 1.3:1 prior to use as a clouding agent.

#### Claims

1. An edible fat mimetic compound of the formula



where

A is an aliphatic chain having 7 to 28 carbon atoms,

$n = 0$  to 2, and

$F_1$  and  $F_2$  are aliphatic groups having 1 to 30 carbon atoms,

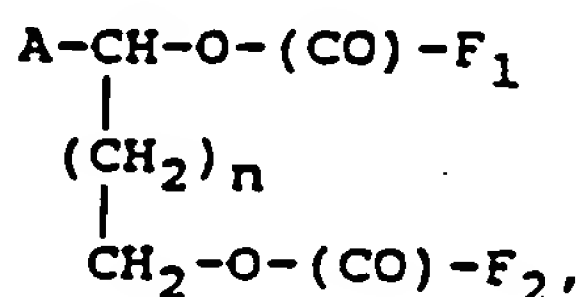
5 or dicarboxylate-extended aliphatic groups of the formula

$-(CH_2)_m-(CO)-O-R$ ,

where  $m = 1$  to 4, and R contains 1 to 30 carbon atoms.

2. The compound according to claim 1 wherein  $n = 0$ , A contains 9 to 28 carbon atoms, and  $F_1$  and  $F_2$  contain 3 to 23 carbon atoms.
- 10 3. The compound according to claim 1 wherein  $n = 1$ , A contains 8 to 27 carbon atoms, and  $F_1$  and  $F_2$  contain 3 to 23 carbon atoms.
4. The compound according to claim 1 wherein  $n = 2$ , A contains 7 to 26 carbon atoms, and  $F_1$  and  $F_2$  contain 3 to 23 carbon atoms.
5. The compound according to any one of claims 1-4 wherein the F groups are derived from fatty acids
  - 15 selected from the group consisting of acetic, propionic, butyric, caproic, caprylic, pelargonic, capric, undecanoic, lauric, myristic, palmitic, stearic, arachidic, behenic, oleic, linoleic, linolenic, eleostearic, and arachidonic acids, and mixtures thereof.
6. The compound according to any one of claims 1-4 wherein the F groups are derived from an oil selected from the group consisting of non-hydrogenated and hydrogenated soybean, safflower, sunflower, sesame,
  - 20 peanut, corn, olive, rice bran, canola, babassu nut, coconut, palm kernel, cottonseed, palm, and butter oils, and fractions thereof.
7. The product according to any one of claims 1-4 wherein  $F_1$  and  $F_2$  are dicarboxylate-extended aliphatic groups selected from the group consisting of malonyl-, succinyl-, glutaryl-, and adipoyl-  $C_1$  to  $C_{30}$  aliphatic groups.
- 25 8. An edible fat product suitable as a fat replacement in foods comprising 11- to 30-carbon aliphatic chains having two vicinal fatty acid ester groups at one end of each chain.
9. The product according to claim 8 wherein the fatty acid ester groups comprise  $C_3$  to  $C_{23}$  fatty acid ester groups.
10. The product according to claim 8 wherein the fatty acid ester groups are selected from the group
  - 30 consisting of butyric, caproic, caprylic, pelargonic, capric, undecanoic, lauric, myristic, palmitic, stearic, arachidic, behenic, oleic, linoleic, linolenic, eleostearic, and arachidonic acid ester groups, and mixtures thereof.
11. The product according to claim 8 wherein the fatty acid ester groups are selected from the group consisting of those derived from non-hydrogenated and hydrogenated soybean, safflower, sunflower,
  - 35 sesame, peanut, corn, olive, rice bran, canola, babassu nut, coconut, palm kernel, cottonseed, palm, and butter oils, and fractions thereof.
12.  $C_{11}$  to  $C_{30}$  diol fatty acid diesters as edible fat replacements.
13. The diesters according to claim 12 wherein the diol is selected from the group consisting of  $C_{11}$  to  $C_{20}$  diols having terminal hydroxyl groups.
- 40 14. The diesters according to claim 12 or 13 wherein the fatty acid(s) comprise  $C_2$  to  $C_{31}$  fatty acid(s).
15. The diesters according to claim 12 or 13 wherein the fatty acid(s) are selected from the group consisting of butyric, caproic, caprylic, pelargonic, capric, undecanoic, lauric, myristic, palmitic, stearic, arachidic, behenic, oleic, linoleic, linolenic, eleostearic, and arachidonic acids, and mixtures thereof.
16. The diesters according to claim 12 or 13 wherein the fatty acids are derived from oils selected from the
  - 45 group consisting of nonhydrogenated and hydrogenated soybean, safflower, sunflower, sesame, peanut, corn, olive, rice bran, canola, babassu nut, coconut, palm kernel, cottonseed, palm, and butter oils, and fractions thereof.
17. 1,2-Dodecane, 1,2-tetradecane, and 1,2-hexadecane diol fatty acid diesters as edible fat replacements.
18. The diesters according to claim 17 wherein the fatty acid diesters comprise those derived from  $C_2$  to
  - 50  $C_{31}$  fatty acids.
19. An edible fat compound comprising the dicarboxylate-extended fatty acid diesters of a diol having 11 to 20 carbon atoms.
20. The compound of claim 19 wherein the dicarboxylate-extended fatty acid diesters comprise  $C_1$  to  $C_{30}$  fatty alcohols reacted with dicarboxylic acids selected from the group consisting of malonic, succinic,
  - 55 glutaric, and adipic acids.
21. A process for synthesizing an edible fat product comprising reacting a diol having 11 to 30 carbons with a fatty acid or a fatty acid derivative selected from the group consisting of a fatty acid, a fatty acid chloride, a fatty acid methyl ester, or a dicarboxylate-extended fatty alcohol.

22. The process of claim 21 wherein said diol comprises  $C_{11}$  to  $C_{20}$  diols and said fatty acids comprise  $C_2$  to  $C_{31}$  fatty acids.
23. The process of claim 21 wherein said diol comprises  $C_{11}$  to  $C_{20}$  diols and said dicarboxylate-extended fatty acids comprise malonyl-, succinyl- and glutaryl- extended  $C_3$  to  $C_{23}$  fatty acids.
- 5 24. A method for reducing the available calories in a food composition having an edible oil component, which method consists of replacing at least a substantial portion of the edible oil with a  $C_{11}$  to  $C_{30}$  diol fatty acid diester or dicarboxylate-extended fatty alcohol diester.
25. The method according to claim 24 wherein said diol comprises  $C_{11}$  to  $C_{20}$  diol.
26. The method of according claim 24 or 25 wherein the fatty acid diesters comprise  $C_3$  to  $C_{23}$  fatty acid
- 10 diesters.
27. The method according to claim 24 wherein the dicarboxylate-extended fatty acid diesters are selected from the group consisting of malonyl-, succinyl-, glutaryl-, and adipoyl-extended  $C_3$  to  $C_{23}$  fatty alcohol diesters.
28. The method according to any one of claims 24-27 wherein said diester is partially digestible.
- 15 29. A food composition comprising an edible fat ingredient of the formula



- where
- 25 A is an aliphatic chain having 7 to 28 carbon atoms,  
 $n = 0$  to 2, and  
 $F_1$  and  $F_2$  are aliphatic groups having 1 to 30 carbon atoms,  
or dicarboxylate-extended aliphatic groups of the formula  
 $-(\text{CH}_2)_m-(\text{CO})-\text{O}-\text{R}$ , where  $m = 1$  to 4, and
- 30 R contains 1 to 30 carbons.
30. The composition according to claim 29 wherein A has from 9 to 18 carbon atoms and  $n = 0$ .
31. The composition according to claim 29 wherein said F groups are aliphatic groups having 3 to 23 carbon atoms.
32. The composition according to claim 29 wherein said F groups are dicarboxylate-extended  $C_3$  to  $C_{23}$
- 35 aliphatic groups.
33. The composition according to claim 29 wherein said food composition comprises a cookie.
34. The composition of claim 33 further comprising sugar, salt, sodium bicarbonate, water, dextrose solution, and flour.
35. The composition of claim 33 further comprising sugar, flour, salt, monocalcium phosphate, sodium
- 40 bicarbonate, vanillin, water, margarine and chocolate chips or butterscotch bits.
36. The composition of claim 29 wherein said food composition comprises candy.
37. The composition of claim 36 wherein said candy is chocolate further comprising cocoa powder and sugar.
38. The composition of claim 37 further processed to form chocolate chips.
- 45 39. The composition of claim 29 wherein said food composition comprises a dairy product.
40. The composition of claim 39 wherein said dairy product is selected from the group consisting of filled cream, filled milk, ice cream, and cheese.
41. The composition of claim 40 wherein said filled cream and filled milk further comprise skim milk.
42. The composition of claim 40 wherein said ice cream further comprises skim milk, sugar, gelatin, flavor
- 50 and color.
43. The composition of claim 29 wherein said food composition is butter cream icing.
44. The composition of claim 43 further comprising sugar, water, non-fat dry milk, emulsifier, salt and vanilla.
45. The composition of claim 29 wherein said food composition is a cracker.
- 55 46. The composition of claim 45 further comprising flour, sugar, malt, sodium bicarbonate, nonfat dry milk, high fructose corn syrup, monocalcium phosphate and water.
47. The composition of claim 29 wherein said food composition is mayonnaise.
48. The composition of claim 47 further comprising egg yolk, vinegar, salt, sugar, flavor, and water.

49. The composition of claim 29 wherein said food composition is a pudding.
50. The composition of claim 49 further comprising milk, sugar, starch, water and flavor.
51. The composition of claim 29 wherein said food composition is a frying oil.
52. The composition of claim 51 further comprising polydimethylsiloxane.
- 5 53. The composition of claim 52 wherein said food composition comprises a pet food.
54. The composition of claim 53 further comprising hominy feed, meat meal, wheat shorts, corn germ meal, wheat germ meal, dried milk, beet pulp, fish scrap, brewer's yeast, salt, vitamins and minerals.
55. The composition of claim 29 wherein said food composition comprises margarine.
56. The composition of claim 55 further comprising soybean hardstock, emulsifier, water, milk solids, salt,  
10 citric acid, and beta carotene.
57. In a food composition, an improvement wherein at least a portion of the digestible fat ingredient is replaced by a C<sub>11</sub> to C<sub>20</sub> diol terminally esterified fatty acid diester.
58. The improvement according to claim 57 wherein the fatty acids are selected from the group consisting of C<sub>3</sub> to C<sub>23</sub> fatty acids.
- 15 59. The improvement according to claim 57 wherein said terminally esterified diol diester delivers 0.5 to 8.5 kcal/gram upon being metabolized.
60. An edible food composition comprising the fatty acid diesters of a terminally esterified C<sub>11</sub> to C<sub>30</sub> diol as a low calorie fat ingredient.

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# EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 90306896.3
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
A	EP - A2 - 0 161 114 (UNILEVER) * Examples 1,2; claims 23-28 *	1, 21	C 07 C 69/00 C 07 C 69/28 C 07 C 69/533 C 07 C 69/58
A	FR - A - 1 405 778 (LONZA) * Totality *	1, 21	C 07 C 69/40 C 07 C 67/00 A 23 C 11/02
A	GB - A - 1 293 277 (RUHRCHEMIE) * Totality *	1, 21	A 23 C 20/02 A 23 D 9/00 A 23 G 1/00 A 23 L 1/19
A	DE - A1 - 3 338 547 (RUHRCHEMIE) * Claims *	1, 21	
A	EP - A2 - 0 249 148 (HENKEL) * Claim 1; examples *	1, 21	
A	GB - A - 1 135 647 (GRACE & CO.) * Totality *	1, 21	TECHNICAL FIELDS SEARCHED (Int. CL.5)
D, A	EP - A2 - 0 254 547 (ATLANTIC RICHFIELD) * Page 4, line 54; page 7, line 25 *	1, 21, 29	C 07 C 69/00 A 23 C A 23 D A 23 G A 23 L
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D, A	US - A - 2 993 063 (W. GODFREY et al.) * Totality *	1, 21, 29, 37	
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 08-10-1990	Examiner HOFBAUER
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			